THE EFFECTS OF FUSEL OIL WATER CONTENT REDUCTION ON PERFORMANCE AND EMISSIONS OF SI ENGINE WITH FUSEL OIL –GASOLINE BLENDED FUEL

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Doctor of Philosophy

Faculty of Mechanical Engineering

UNIVERSITI MALAYSIA PAHANG

March 2018

ACKNOWLEDGEMENTS

In the name of Allah, and all praise be to Allah, and prayers and peace be upon the Messenger of Allah, his family, his companions, and those who followed him. Grateful to Allah because of His grace, these studies have been carried out successfully.

I would like to express my special appreciation and thanks to my supervisor—Professor Dr. Rizalman Mamat. Prof. Rizalman is always happy and willing to help me solve the confusions and direct me to the final result of the thesis.

I am thankful to Universiti Malaysia Pahang (UMP) for the flagship research grant (RDU172204) and FRGS research grant (RDU130131). My thank also go to the FKM and IPS staff for their assisting and kind helpful.

A special thanks to my family. Words cannot express how grateful I am to my mother, and father for all the sacrifices that you've made on my behalf. Your prayer for me was what sustained me thus far. I would also like to thank all my friends who supported me in writing, and incentivized me to strive towards my goal.

ABSTRAK

Keselamatan tenaga dan pemanasan global adalah dua daya penggerak utama bagi pembangunan alkohol dunia yang juga salah satu usaha untuk membangunkan industri pertanian. Secara amnya, bahan api alkohol dihasilkan dari beberapa sumber dan mempunyai nilai pemanasan yang rendah berbanding bahan bakar fosil. Nilai oktana penyelidikan dan nilai oktana motor yang tinggi kandungan oksigen yang tinggi (30.23% wt) dan titik mendidih tunggal minyak fusel telah menunjukkan bahawa ia boleh digunakan sebagai bahan bakar dalam enjin SI. Sebaliknya, kandungan air yang lebih tinggi dalam minyak fusel iaitu sekitar (10-20%) menghasilkan nilai pemanasan minyak fusel yang lebih kecil sebanyak 31% berbanding petrol. Kandungan air yang lebih tinggi dalam minyak fusel memberi kesan negatif terhadp kecekapan pembakaran, oleh kerana itu prestasi enjin dan pelepasan akan terjejas. Analisis komprehensif terhadap sifat-sifat, prestasi dan pelepasan daripada minyak fusel telah dilakukan. Data sifat-sifat minyak fusel-petrol dianalisis secara statistik dengan cara yang berbeza untuk menunjukkan kesan sebelum dan selepas pengekrakan air daripada minyak fusel terhadap sifat-sifat bahan api yan diuji. Ujikaji yang dijalankan keatas enjin SI suntikan langsung dijalankan dengan menggunakan campuran minyak fusel-petrol dan petrol yang asli telah digunakan sebagai bahan api asas pada kedudukan injap pendikit terbuka yang berbeza (% WOT) sebagai beban enjin dan kelajuan enjin (rpm). Metodologi tindakbalas permukaan (RSM) berasaskan penyesuaian pelbagai objektif telah digunakan dalam kajian ini untuk menentukan nisbah campuran optimum minyak fusel sebelum dan selepas pengekstrakan air (FBWE10, FBWE20, FAWE10, dan FAWE20) terhadap prestasi dan pelepasan. Nilai pemanasan dan kandungan karbon dalam minyak fusel memberi kesan positif yang ketara selepas pengekrakan kandungan air sebanyak 13% dan 7%, sementara itu kandungan oksigen telah berkurang. Menurut analisis statistik daripada hasil ujian sifat bahan api (campuran fusel minyak-petrol), nilai pemanasan, kandungan oksigen, dan kandungan karbon mempunyai kesan ketara secara statistik terhadap ujian bahan api setelah pecahan minyak fusel meningkat terutamanya selepas pengekstrakan kandungan air Kuasa enjin telah bertambah baik dengan pengekstrakan kandungan air dan kuasa brek tertinggi telah dicapai FAWE10 di bawah bahan bakar kaya (λ <1). BSFC yang terendah dilaporkan adalah 275 g / kW.h pada petrol manakala BSFC tertinggi adalah FBWE10 yang dilaporkan pada 285 g / kW.h. Selain itu, BSFC telah menurun secara purata sebanyak 6.8% dan 1.7% yang mana dibandingkan masing-masing antara FAWE10 dan FBWE0, FAWE20 dan FBWE20. Kandungan air dalam minyak fusel menyebabkan pengurangan dalam pembakaran enjin menyebabkan pembebasan NOx berkurang. Bahan api campuran mempunyai kesan yang tidak ketara terhadap kuasa brek sementara kesan bahan api campuran yang paling ketara adalah pada tindak BTE dan BSFC. Kandungan air yang diekstrak dari minyak fusel (FAWE10 dan FAWE20) mempunyai kepentingan statistik untuk meningkatkan BTE, pelepasan NO_x dan mengurangkan BSFC dan pelepasan hydrocarbon (HC) dan tidak memberi kesan yang ketara terhadap kuasa brek . Oleh itu, penyelesaian terbaik adalah dengan 20% campuran minyak fusel selepas air diekstrak (FAWE20) pada beban dan kelajuan enjin yang lebih tinggi. Akhir sekali, hasil daripada ujian pengesahan menunjukkan persetujuan yang baik dengan data ujikaji dan peratusan maksimum ralat adalah kurang daripada 5%. Penemuan kajian ini akan memberi sumbangan besar kepada penggunaan masa hadapan bahan api fusel dalam enjin pembakaran dalaman dengan meningkatkan nilai pemanasan

ABSTRACT

Energy security and global warming concerns are the two main driving forces for the global alcohol development that also has the effort to animate the agro-industry. Generally, alcohol fuels are produced from several sources and have less heating value then fossil fuel. Fusel oil is a by-product obtained through the fermentation of some agricultural products such as beets, cones, grains, potatoes, sweet potatoes, rice and wheat. The high research octane number and motor octane number (RON 106 and MON 103), high oxygen content (30.23% wt) and single boiling point of fusel oil indicated it can be used as a fuel in SI engines. On the other hand, the higher water content of fusel oil (around 10-20%) led to a lower heating value by 31% compared to gasoline. Also, the higher water content of fusel oil effect negatively on the combustion duration, thereby engine performance and emission are affected. Comprehensive analyses of the fusel oil properties, performance and emissions have been performed. The data of fusel oil-gasoline properties were analyzed statistically in different ways to indicate the effects of fusel oil before and after water content extraction on the test fuels properties. The experimental conducted with direct injection SI engine run with fusel oil-gasoline blends and pure gasoline as the baseline fuel at different open throttle valve positions (% of WOT) as engine loads and engine speeds (rpm). Response surface methodology (RSM) based multi-objective optimization was applied in this work to determine the optimal blend ratio of fusel oil –gasoline before and after water extraction (FBWE10, FBWE20, FAWE10, and FAWE20) on the performance and emissions. The heating value and carbon content of fusel oil improved significantly after extracting the water content by 13% and 7%, respectively, while the oxygen content reduced. According to the statistical analysis of test fuel properties results (fusel oil-gasoline blends), the heating value, oxygen, and carbon content have statistically significant effects on the test fuels as the fraction of fusel oil increased especially after water content extraction. The engine power has improved with the extraction of water content and the highest brake power is registered with FAWE10 under rich fuel (λ<1). The lowest brake specific fuel consumption (BSFC) is reported to be 275 g/kW.h with gasoline while the highest BSFC is with FBWE10 which is reported to be 285 g/kW.h. Furthermore, the BSFC has decreased on average by 6.8% and 1.7% with FAWE10 and FAWE20, compared to FBWE 10 and FAWE20 respectively. The water content of fusel oil led to the limitation of the engine combustion thereby the NO_x emission reduced. The blended fuel has insignificant effects on brake power while the highest impact of blended fuel was on BTE and BSFC responses. The extracted water content from fusel oil (FAWE10 and FAWE20) has a statistical significance in order to increase the brake thermal efficiency (BTE), NO_x emission and decrease the brake specific fuel consumption (BSFC) and HC emissions while having insignificant effects on brake power. Thus, the best solution was with 20% of fusel oil after water extraction (FAWE20) at higher load and engine speed. Finally, the validation of the results showed a good agreement with the experimental data and the maximum percentage of error which is less than 5%.The findings from this study will make significant contributions to the future applications of fusel fuel in an internal combustion engine by improving the heating value.

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LIST OF SYMBOLS

k	Ratio of specific heat
θ	Crank angle (degree)
μ	Dynamic viscosity (cp)
BP	Brake power (kW)
C	Carbon content (%)
H	Hydrogen content (%)
mf	Fuel mass flow rate (g/hr)
N	Nitrogen content (%)
N	Engine speed (rpm)
NC	Number of cycles
O	Oxygen content (%)
p	Cylinder pressure (bar)
S	Sulphur content (%)
T	Torque (N.m)
V	Cylinder volume (cm^3)
λ	Relative fuel-air ratio
ν	Kinematic viscosity (mm^2/s)
ρ	Density (kg/m^3)

LIST OF ABBREVIATIONS

AK	Anti-knocking
ANOVA	Analysis of variance
ASTM	American society of testing materials
ATDC	After top dead centre
BMEP	Brake mean effect pressure
BP	Brake power
BSFC	Brake specific fuel consumption
BTDC	Before top dead centre
BTE	Brake thermal efficiency
Btu	British thermal unit
CAD	Crank angle degree
CD	Combustion duration
CE	Combustion efficiency
CFR	Cooperative fuels research
CN	Cetane number
CO	Carbon monoxide
CO2	Carbon dioxide
COI	Cone of influence
COV	Coefficient of variation
CR	Compression ratio
CS	Combustion speed,
CT	Cylinder temperature
CWT	Continuous wavelet transforms
DF	Degree of freedom
DI	Direct injection
DISI	Direct injection spark ignition
DME	Dimethyl ether CH3OCH3
DMF	Dimethylfuran
DoE	Design of Experiment
DST	Different Spark timing
EGR	Exhaust gas recirculation
F0	100% Gasoline
FAWE	Fusel oil After water extraction by volume
FAWE20	90% Gasoline + 10% fusel oil after water extraction by volume

FAWE20	80% Gasoline + 20% fusel oil after water extraction
FBWE	Fusel oil before water extraction
FBWE10	90% Gasoline + 10% fusel oil before water extraction
FBWE10	80% Gasoline + 20% fusel oil before water extraction
FS	Flame speed
GC-MS	Gas Chromatography–Mass Spectrometry
GHG	Greenhouse gases
H	Hydrogen
HC	Hydrocarbon
HCCI	Homogeneous charge compression ignition
HHV	Higher heating value
HSD	Honest significant difference
ICE	Internal combustion engine
LHOV	Latent heat of vaporization
LHV	Lower heating value
LUC	Land-use change
MFB	Mass fraction burned
MTBE	Methyl tertiary-butyl ether
NAP	National alcohol program
POAE	Percentage of absolute error
PST	Phase Separation Temperature
REP	Reid evaporation pressure
ROHR	Rate of Heat Release
ROPR	rate of pressure rise
SFC	Specific fuel consumption
SSd	Sum of the squared deviations
SSt	Total sum of squared deviations
TCD	Thermal conductivity detectors
TEL	Tetraethyl lead

5.4 REFERENCES

Abbasi, T., & Abbasi, S. A. (2010). Biomass energy and the environmental impacts associated with its production and utilization. Renewable and Sustainable Energy Reviews, 14(3), 919-937. doi: http://dx.doi.org/10.1016/j.rser.2009.11.006

Achten, C., Kolb, A., & Püttmann, W. (2001). Methyl tert-butyl ether (MTBE) in urban and rural precipitation in Germany. Atmospheric Environment, 35(36), 6337-6345. doi: http://dx.doi.org/10.1016/S1352-2310(01)00423-X

Agarwal, A. K. (2007). Biofuels (alcohols and biodiesel) applications as fuels for internal combustion engines. Progress in energy and combustion science, 33(3), 233-271.

Agarwal, A. K., Dhar, A., Gupta, J. G., Kim, W. I., Choi, K., Lee, C. S., & Park, S. (2015). Effect of fuel injection pressure and injection timing of Karanja biodiesel blends on fuel spray, engine performance, emissions and combustion characteristics. Energy Conversion and Management, 91, 302-314.

Agarwal, D., Sinha, S., & Agarwal, A. K. (2006). Experimental investigation of control of NOx emissions in biodiesel-fueled compression ignition engine. Renewable Energy, 31(14), 2356-2369.

Ainsworth, S. (1992). Oxygenates seen as hot market by industry (Vol. 70, pp. 26-&): American Chemical Society 1155 16th St, New Washington DC 20036.

Al-Hasan, M. (2003). Effect of ethanol–unleaded gasoline blends on engine performance and exhaust emission. Energy Conversion and Management, 44(9), 1547-1561.

Alasfour, F. (1998). NO x Emission from a spark ignition engine using 30% Iso-butanol–gasoline blend: part 1—preheating inlet air. Applied thermal engineering, 18(5), 245-256.

Ali, O. M., Mamat, R., Abdullah, N. R., & Abdullah, A. A. (2016). Analysis of blended fuel properties and engine performance with palm biodiesel–diesel blended fuel. Renewable Energy, 86, 59-67.

Alptekin, E., & Canakci, M. (2009). Characterization of the key fuel properties of methyl ester–diesel fuel blends. Fuel, 88(1), 75-80.

Ambrós, W. M., Lanzanova, T. D. M., Fagundez, J. L. S., Sari, R. L., Pinheiro, D. K., Martins, M. E. S., & Salau, N. P. G. (2015). Experimental analysis and modeling of internal combustion engine operating with wet ethanol. Fuel, 158, 270-278. doi: http://dx.doi.org/10.1016/j.fuel.2015.05.009

Anand, K., & Mehta, P. (2009). Estimation of a lower heating value of vegetable oil and biodiesel fuel.

Anderson, J. E., DiCicco, D. M., Ginder, J. M., Kramer, U., Leone, T. G., Raney-Pablo, H. E., & Wallington, T. J. (2012). High octane number ethanol–gasoline blends: Quantifying the potential benefits in the United States. Fuel, 97, 585-594. doi: http://dx.doi.org/10.1016/j.fuel.2012.03.017

Anggarani, R., Wibowo, C. S., & Sukaraharja, R. (2015). Performance and Emission Characteristics of Dimethyl Ether (DME) Mixed Liquefied Gas for Vehicle (LGV) as Alternative Fuel for Spark Ignition Engine. Energy Procedia, 65, 274-281.

Ann, V. B. H. a. C. M. (2007). A review of assessments conducted on bio-ethanol as a transportation fuel from a net energy, greenhouse gas, and environmental life cycle perspective. Journal of cleaner production, 15(7), 607-619.

Annamalai, K., Sweeten, J., & Ramalingam, S. (1987). Technical Notes: Estimation of gross heating values of biomass fuels. Transactions of the ASAE, 30(4), 1205-1208.

Arcoumanis, C. (2000). The second European auto-oil programme (AOLII). European Commission, 2.

Assc, R. F. (Accessed 12 May 2017). Ethanol Industry Outlook, Fueling High OctaneFuture. Renewable Fuels Association

Atadashi, I. M., Aroua, M. K., Abdul Aziz, A. R., & Sulaiman, N. M. N. (2012). The effects of water on biodiesel production and refining technologies: A review. Renewable and Sustainable Energy Reviews, 16(5), 3456-3470. doi: http://dx.doi.org/10.1016/j.rser.2012.03.004

Atmanlı, A., İleri, E., & Yüksel, B. (2015). Effects of higher ratios of n-butanol addition to diesel–vegetable oil blends on performance and exhaust emissions of a diesel engine. Journal of the Energy Institute, 88(3), 209-220. doi: http://dx.doi.org/10.1016/j.joei.2014.09.008

Atnaw, S. M., Sulaiman, S. A., & Yusup, S. (2014). Influence of fuel moisture content and reactor temperature on the calorific value of syngas resulted from gasification of oil palm fronds. The Scientific World Journal, 2014.

Augoye, A., & Aleiferis, P. (2014). Characterization of Flame Development with Hydrous and Anhydrous Ethanol Fuels in a Spark-Ignition Engine with Direct Injection and Port Injection Systems: SAE Technical Paper.

Awad, O. I., Mamat, R., Ali, O. M., Yusri, I. M., Abdullah, A. A., Yusop, A. F., & Noor, M. M. The effect of adding fusel oil to diesel on the performance and the emissions characteristics in a single cylinder CI engine. Journal of the Energy Institute. doi: http://dx.doi.org/10.1016/j.joei.2016.04.004

Ayhan, D. (2008). Biodiesel a Realistic Fuel Alternative for Diesel Engines. ISBN-13: 9781846289941.

Balki, M. K., & Sayin, C. (2014). The effect of compression ratio on the performance, emissions and combustion of an SI (spark ignition) engine fueled with pure ethanol, methanol and unleaded gasoline. Energy, 71, 194-201. doi: http://dx.doi.org/10.1016/j.energy.2014.04.074

Baranski, J. A. (2013). Experimental Investigation of Octane Requirement Relaxation in a Turbocharged Spark-ignition Engine. University of Dayton.

Barth, R. (2013). The Chemistry of Beer: The Science in the Suds: John Wiley & Sons.

Baumert, K. A., Herzog, T., & Pershing, J. (2005). Navigating the numbers: Greenhouse gas data and international climate policy: World Resources Inst.

Bernard, J.-T., Gavin, M., Khalaf, L., & Voia, M. (2015). Environmental Kuznets Curve: Tipping Points, Uncertainty and Weak Identification. Environmental and Resource Economics, 60(2), 285-315.

Beychok, M. Tetraethyl lead (TEL).

Bielański, A., Małecka-Lubańska, A., Poźniczek, J., Micek-Ilnicka, A., Hamid, H., & Ali, M. (2004). Handbook of MTBE and Other Gasoline Oxygenates: Marcel Dekker Inc., New York.

Bilgin, I. s. S. a. A. (2008). Effects of Methyl tert-Butyl Ether Addition to Base Gasoline on the Performance and CO Emissions of a Spark Ignition Engine. Energy & Fuels, 2008, (22,), 1341-1348.

Bo, Z., Weibiao, F., & Jingsong, G. (2006). Study of fuel consumption when introducing DME or ethanol into diesel engine. Fuel, 85(5), 778-782.

Bourne, J. K., Clark, Robert. (2007). Green dreams. National Geographic, 212(4), 38-59.

Box, G. E., & Wilson, K. (1992). On the experimental attainment of optimum conditions Breakthroughs in Statistics (pp. 270-310): Springer.

Brandberg, A., Hedbom, A., Isaksson, K., & Laveskog, A. (1987). Project M100-a Test with Methanol-fueled Vehicles in Sweden.

Brau, H. M. (2010). Review on the origin and composition of fusel oil.

Brinkman, N., Ecklund, E., & Nichols, R. (1975). Fuel Methanol: A Decade of Progress, Society of Automotive Engineers. Inc, Warrendale, USA.

Brinkman, N., Gallopoulos, N., & Jackson MW. (1975). Exhaust emissions, fuel economy, and driveability of vehicles fueled with alcohol-gasoline blends: SAE Technical Paper.

Brown, R., & Wines, T. (1993). Improve suspended water removal from fuels. Hydrocarbon Processing, 72, 95-95.

Cairns, A., Stansfield, P., Fraser, N., Blaxill, H., Gold, M., Rogerson, J., & Goodfellow, C. (2009). A study of gasoline-alcohol blended fuels in an advanced turbocharged DISI engine. SAE International Journal of Fuels and Lubricants, 2(1), 41-57.

Calam, A., İçingür, Y., Solmaz, H., & Yamık, H. (2013). A Comparison of Engine Performance and Emissions of Fusel Oil and Gasoline Mixtures at Different Ignition Timings. International Journal of Green Energy(just-accepted).

Calam, A., İçingür, Y., Solmaz, H., & Yamık, H. (2015). A Comparison of Engine Performance and the Emission of Fusel Oil and Gasoline Mixtures at Different Ignition Timings. International Journal of Green Energy, 12(8), 767-772.

Calam, A., Solmaz, H., Uyumaz, A., Polat, S., Yilmaz, E., & Içingür, Y. (2014). Investigation of usability of the fusel oil in a single cylinder spark ignition engine. Journal of the Energy Institute.

Calam, A., Solmaz, H., Uyumaz, A., Polat, S., Yilmaz, E., & İçingür, Y. (2015). Investigation of usability of the fusel oil in a single cylinder spark ignition engine. Journal of the Energy Institute, 88(3), 258-265. doi: http://dx.doi.org/10.1016/j.joei.2014.09.005

Callejón-Ferre, A., Velázquez-Martí, B., López-Martínez, J., & Manzano-Agugliaro, F. (2011). Greenhouse crop residues: energy potential and models for the prediction of their higher heating value. Renewable and Sustainable Energy Reviews, 15(2), 948-955.

Canakci, M., Ozsezen, A. N., Alptekin, E., & Eyidogan, M. (2013). Impact of alcohol–gasoline fuel blends on the exhaust emission of an SI engine. Renewable Energy, 52, 111-117. doi: http://dx.doi.org/10.1016/j.renene.2012.09.062

Çelik, M. B., Özdalyan, B., & Alkan, F. (2011). The use of pure methanol as fuel at high compression ratio in a single cylinder gasoline engine. Fuel, 90(4), 1591-1598. doi: http://dx.doi.org/10.1016/j.fuel.2010.10.035

Channiwala, S., & Parikh, P. (2002). A unified correlation for estimating HHV of solid, liquid and gaseous fuels. Fuel, 81(8), 1051-1063.

Chong, J., Tsolakis, A., Gill, S., Theinnoi, K., & Golunski, S. E. (2010). Enhancing the NO 2/NOx ratio in compression ignition engines by hydrogen and reformate combustion, for improved aftertreatment performance. International journal of hydrogen energy, 35(16), 8723-8732.

Christensen, E., Yanowitz, J., Ratcliff, M., & McCormick, R. L. (2011). Renewable oxygenate blending effects on gasoline properties. Energy & Fuels, 25(10), 4723-4733.

Christensen, M., & Johansson, B. (1999). Homogeneous charge compression ignition with water injection: SAE Technical Paper.

Cooper, C. D., & Alley, F. C. (2002). Air pollution control: A design approach: Waveland Press.

Costa, R. C., & Sodré, J. R. (2010). Hydrous ethanol vs. gasoline-ethanol blend: Engine performance and emissions. Fuel, 89(2), 287-293.

Costa, R. C., & Sodré, J. R. (2011). Compression ratio effects on an ethanol/gasoline fuelled engine performance. Applied thermal engineering, 31(2–3), 278-283. doi: http://dx.doi.org/10.1016/j.applthermaleng.2010.09.007

Daniel, R., Tian, G., Xu, H., & Shuai, S. (2012). Ignition timing sensitivities of oxygenated biofuels compared to gasoline in a direct-injection SI engine. Fuel, 99, 72-82. doi: http://dx.doi.org/10.1016/j.fuel.2012.01.053

Daniel, R., Tian, G., Xu, H., Wyszynski, M. L., Wu, X., & Huang, Z. (2011). Effect of spark timing and load on a DISI engine fuelled with 2,5-dimethylfuran. Fuel, 90(2), 449-458. doi: http://dx.doi.org/10.1016/j.fuel.2010.10.008

Dauriat, E. G. a. A. (2005). Ethanol fuel from biomass: A review. Journal of Scientific and Industrial Research, 64(11), 809.

De, B., Bose, P., & Panua, R. (2012). An Experimental Investigation on Performance and Emissions Characteristics of Jatropha Oil Blends with Diesel in a Direct Injection Compression Ignition Engine. Journal of The Institution of Engineers (India): Series C, 93(3), 203-208.

Demirbas, A. (2002). Relationships between heating value and lignin, moisture, ash and extractive contents of biomass fuels. Energy, Exploration & Exploitation, 20(1), 105-111.

Demirbas, A. (2004). Combustion characteristics of different biomass fuels. Progress in energy and combustion science, 30(2), 219-230.

Demirbas, A. (2007). Effects of moisture and hydrogen content on the heating value of fuels. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 29(7), 649-655.

Demirbas, A. (2009). Political, economic and environmental impacts of biofuels: A review. Applied Energy, 86, S108-S117.

Demirbaş, A. (1997). Calculation of higher heating values of biomass fuels. Fuel, 76(5), 431-434.

Demirbas, A., Balubaid, M., Basahel, A., Ahmad, W., & Sheikh, M. (2015). Octane Rating of Gasoline and Octane Booster Additives. Petroleum Science and Technology, 33(11), 1190-1197.

Demirbas, A., Gullu, D., Caglar, A., & Akdeniz, F. (1997). Estimation of calorific values of fuels from lignocellulosics. Energy sources, 19(8), 765-770.

Dhaliwal, B., Yi, N., & Checkel, D. (2000). Emissions effects of alternative fuels in light-duty and heavy-duty vehicles: SAE Technical Paper.

Dhamodaran, G., Esakkimuthu, G. S., & Pochareddy, Y. K. (2016). Experimental study on performance, combustion, and emission behaviour of diisopropyl ether blends in MPFI SI engine. Fuel, 173, 37-44. doi: http://dx.doi.org/10.1016/j.fuel.2016.01.014

Dimitroff, E., & Vitkovits, J. A. (1980). Blend of gasoline and vapors of dissociated alcohol: Google Patents.

Dörmer, W., Hill, S., Jørgensen, R., Kovacs, A., Lermusiaux, A., Lluch-Urpi, J., . . . Heinze, P. (1998). A survey of European gasoline qualities-summer 1996. Concawe Automotive Emissions Management Group, Brussels

Eden, A., Van Nedervelde, L., Drukker, M., Benvenisty, N., & Debourg, A. (2001). Involvement of branched-chain amino acid aminotransferases in the production of fusel alcohols during fermentation in yeast. Applied microbiology and biotechnology, 55(3), 296-300.

Egebäck, K.-E., & Pettersson, E. (1996). Research on a Scania 11 liter ethanol fueled bus engine.

EIA. (2015). International energy outlook. U.S. : Energy Information Administration.

El-Emam, S., & Desoky, A. (1985). A study on the combustion of alternative fuels in spark-ignition engines. International journal of hydrogen energy, 10(7), 497-504.

Elneel, R., Anwar, S., & Ariwahjoedi, B. (2013). Prediction of Heating Values of Oil Palm Fronds from Ultimate Analysis. Journal of Applied Sciences, 13(3), 491.

Emodi, N. V., Emodi, C. C., Murthy, G. P., & Emodi, A. S. A. (2017). Energy policy for low carbon development in Nigeria: A LEAP model application. Renewable and Sustainable Energy Reviews, 68, 247-261.

Energy, D. o. (2014). Light-Duty AFV, HEV, and Diesel Model Offerings, By Fuel Type. from http://www.afdc.energy.gov/data/10303

Englin, B., Kyuregyan, S., Levinson, G., Demidenko, K., & Golosava, V. (1978). Low—temperature properties of gasoline—methanol. ZM—KHIM, 20, 106-110.

Esbenshade, A. J. (2012). Differential Protein Expression and Butanol Production using Clostridium beijerinckii. Youngstown State University.

Eyidogan, M., Ozsezen, A. N., Canakci, M., & Turkcan, A. (2010). Impact of alcohol–gasoline fuel blends on the performance and combustion characteristics of an SI engine. Fuel, 89(10), 2713-2720. doi: http://dx.doi.org/10.1016/j.fuel.2010.01.032

Eyidogan Muharrem, A. N. O., Mustafa Canakci, and Ali Turkcan. (2010). Impact of alcohol–gasoline fuel blends on the performance and combustion characteristics of an SI engine. Fuel, 89(10), 2713-2720.

Fabrikalar, T. S. (2016). cost of fusel oil (Füzel Yağı). from http://www.turkseker.gov.tr/Fiyatlar.aspx

Fahd, M. E. A., Wenming, Y., Lee, P., Chou, S., & Yap, C. R. (2013). Experimental investigation of the performance and emission characteristics of direct injection diesel engine by water emulsion diesel under varying engine load condition. Applied Energy, 102, 1042-1049.

Fang, Q., Fang, J., Zhuang, J., & Huang, Z. (2012). Influences of pilot injection and exhaust gas recirculation (EGR) on combustion and emissions in a HCCI-DI combustion engine. Applied thermal engineering, 48, 97-104. doi: http://dx.doi.org/10.1016/j.applthermaleng.2012.03.021

Feng, R., Yang, J., Zhang, D., Deng, B., Fu, J., Liu, J., & Liu, X. (2013). Experimental study on SI engine fuelled with butanol–gasoline blend and H2O addition. Energy Conversion and Management, 74, 192-200. doi: http://dx.doi.org/10.1016/j.enconman.2013.05.021

Ferreira, M. C., Meirelles, A. J., & Batista, E. A. (2013). Study of the fusel oil distillation process. Industrial & engineering chemistry Research, 52(6), 2336-2351.

French, R., & Malone, P. (2005). Phase equilibria of ethanol fuel blends. Fluid Phase Equilibria, 228–229, 27-40. doi: http://dx.doi.org/10.1016/j.fluid.2004.09.012

Friedl, A., Padouvas, E., Rotter, H., & Varmuza, K. (2005). Prediction of heating values of biomass fuel from elemental composition. Analytica Chimica Acta, 544(1), 191-198.

Gardner, P. N. (2016). Brookfield DV-II+ programmable viscometer. from https://www.gardco.com/pages/viscosity/vi/bf_accessories.cfm#top

Gautam, M., & Martin, D. (2000). Combustion characteristics of higher-alcohol/gasoline blends. Proceedings of the Institution of Mechanical Engineers, Part A: Journal of Power and Energy, 214(5), 497-511.

Ghazali, W. N. M. W., Mamat, R., Masjuki, H., & Najafi, G. (2015). Effects of biodiesel from different feedstocks on engine performance and emissions: A review. Renewable and Sustainable Energy Reviews, 51, 585-602.

Ghazikhani, M., Hatami, M., Safari, B., & Ganji, D. D. (2013). Experimental investigation of performance improving and emissions reducing in a two stroke SI engine by using ethanol additives. Propulsion and Power Research, 2(4), 276-283. doi: http://dx.doi.org/10.1016/j.jppr.2013.10.002

Gillies, B., Yamazaki, H., & Armstrong, D. W. (1987). Production of flavor esters by immobilized lipase. Biotechnology Letters, 9(10), 709-714.

Gopalakannan, S., & Senthilvelan, T. (2013). Application of response surface method on machining of Al–SiC nano-composites. Measurement, 46(8), 2705-2715.

Goswami, A., Vashist, S., & Nayyar, A. (2015). Effect of Compression Ratio on the Performance Characteristics of Spark Ignition Engine Fueled with Alternative Fuels: A Review: SAE Technical Paper.

Graham, P. J., Gregg, David J and Saddler, John N. (2003). Wood-ethanol for climate change mitigation in Canada. Applied biochemistry and biotechnology, 105(1-3), 231-242.

Gu, X., Huang, Z., Cai, J., Gong, J., Wu, X., & Lee, C.-f. (2012). Emission characteristics of a spark-ignition engine fuelled with gasoline-n-butanol blends in combination with EGR. Fuel, 93, 611-617. doi: http://dx.doi.org/10.1016/j.fuel.2011.11.040

Gubicza, L., Nemestóthy, N., Fráter, T., & Bélafi-Bakó, K. (2003). Enzymatic esterification in ionic liquids integrated with pervaporation for water removal. Green Chemistry, 5(2), 236-239.

Gulati, R., Arya, P., Malhotra, B., Prasad, A. K., Saxena, R. K., Kumar, J., . . . Parmar, V. S. (2003). Novel biocatalytic esterification reactions on fatty acids: synthesis of sorbitol 1 (6)-monostearate. Arkivoc, 3, 159-170.

Harijan, K., Memon, M., Uqaili, M. A., & Mirza, U. K. (2009). Potential contribution of ethanol fuel to the transport sector of Pakistan. Renewable and Sustainable Energy Reviews, 13(1), 291-295. doi: http://dx.doi.org/10.1016/j.rser.2007.07.007

Hazelwood, L. A., Daran, J.-M., van Maris, A. J., Pronk, J. T., & Dickinson, J. R. (2008). The Ehrlich pathway for fusel alcohol production: a century of research on Saccharomyces cerevisiae metabolism. Applied and environmental microbiology, 74(8), 2259-2266.

He, B.-Q., Liu, M.-B., Yuan, J., & Zhao, H. (2013). Combustion and emission characteristics of a HCCI engine fuelled with n-butanol–gasoline blends. Fuel, 108, 668-674. doi: http://dx.doi.org/10.1016/j.fuel.2013.02.026

Heywood, J. Internal Combustion Engine Fundamentals[M]. New York: McGraw-Hill Book Company, 1988.

Heywood, J. B. (1988). Internal combustion engine fundamentals (Vol. 930): Mcgraw-hill New York.

Hirose, Y., Ogawa, M., & Kusuda, Y. (1962). Constituents of fusel oils obtained through the fermentation of corn, barley and sweet molasses. Agricultural and Biological Chemistry, 26(8), 526-531.

HOEVEN, M. v. D. (2013). CO2 Emissions From Fuel Combustion IEA Statistics. International Energy Agency: highlights. França: International Energy Agency.

Hough, J., & Stevens, R. (1961). Beer flavour. IV. Factors affecting the production of fusel oil. Journal of the Institute of Brewing, 67(6), 488-494.

Hsieh, Chen, R.-H., Wu, T.-L., & Lin, T.-H. (2002). Engine performance and pollutant emission of an SI engine using ethanol–gasoline blended fuels. Atmospheric Environment, 36(3), 403-410. doi: http://dx.doi.org/10.1016/S1352-2310(01)00508-8

Hsieh, C. W., Huang, Y. H., Lai, C. H., Ho, W. J., & Ko, W. C. (2010). Develop a novel method for removing fusel alcohols from rice spirits using nanofiltration. Journal of food science, 75(2), N25-N29.

Huang, Z., Miao, H., Zhou, L., & Jiang, D. (2000). Technical Note: Combustion characteristics and hydrocarbon emissions of a spark ignition engine fuelled with gasoline-oxygenate blends. Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, 214(3), 341-346.

Huang, Z., Shiga, S., Ueda, T., Nakamura, H., Ishima, T., Obokata, T., . . . Kono, M. (2003). Study of cycle-by-cycle variations of natural gas direct injection combustion using a rapid compression machine. Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, 217(1), 53-61.

Hughes, K. Treatise on Alcohol-Blended Gasoline: Phase Separation and Alcohol Monitors: Citeseer.

Hund, G., Laverty, K., Mahy, H., Szabo, C., & Woods, L. (2003). 200 Proof Transportation: The potential for Ethanol as an Alternative Fuel. University of Washington, Global Commercialization of Environmental Technologies.

I. Ay, O. Recepouglu, & Tolun, R. (1994, Turkey). Utilization of Fusel Oil. National Chem. Eng. Symp., (in Turkish).. 6.

Ihara, T., Tanaka, T., & Wakai, K. (2009). Effects of octane number on autoignition and knocking phenomena in a stratified mixture. Combustion, Explosion, and Shock Waves, 45(4), 428-434.

Imran, A., Varman, M., Masjuki, H. H., & Kalam, M. A. (2013). Review on alcohol fumigation on diesel engine: A viable alternative dual fuel technology for satisfactory engine performance and reduction of environment concerning emission. Renewable and Sustainable Energy Reviews, 26, 739-751. doi: http://dx.doi.org/10.1016/j.rser.2013.05.070

Ismet, B. A. a. S. (2008). Effects of methanol addition to gasoline on the performance and fuel cost of a spark ignition engine. Energy & Fuels, 22(4), 2782-2788.

J., M., Moran, P., A. Hamilton, & Zogorski, J. S. (2013). Volatile Organic Compounds in the Nation’s Ground Water and Drinking-Water Supply Wells—A Summary. USGS.

Jacobs, P. B., & Newton, H. P. (1938). Motor fuels from farm products: US Department of Agriculture.

Jenkins, B., & Ebeling, J. (1985). Correlation of physical and chemical properties of terrestrial biomass with conversion.

Jeuland, N., Montagne, X., & Gautrot, X. (2004). Potentiality of ethanol as a fuel for dedicated engine. Oil and Gas Science and Technology, 59(6), 559-570.

Jeuland, N., Montagne, X., & Gautrot, X. (2004). Potentiel de l'éthanol en tant que carburant pour un moteur dédié. Oil & Gas Science and Technology - Rev. IFP, 59(6), 559-570.

Ji, C., Liang, C., & Wang, S. (2011). Investigation on combustion and emissions of DME/gasoline mixtures in a spark-ignition engine. Fuel, 90(3), 1133-1138. doi: http://dx.doi.org/10.1016/j.fuel.2010.11.033

Ji, C., Liang, C., Zhu, Y., Liu, X., & Gao, B. (2012). Investigation on idle performance of a spark-ignited ethanol engine with dimethyl ether addition. Fuel Processing Technology, 94(1), 94-100.

Ji, C., & Wang, S. (2009). Effect of hydrogen addition on combustion and emissions performance of a spark ignition gasoline engine at lean conditions. International journal of hydrogen energy, 34(18), 7823-7834. doi: http://dx.doi.org/10.1016/j.ijhydene.2009.06.082

Jin, C., Yao, M., Liu, H., Lee, C.-f. F., & Ji, J. (2011). Progress in the production and application of n-butanol as a biofuel. Renewable and Sustainable Energy Reviews, 15(8), 4080-4106. doi: http://dx.doi.org/10.1016/j.rser.2011.06.001

Johnson, R., Pankow, J., Bender, D., Price, C., & Zogorski, J. (2000). Peer Reviewed: MTBE—To What Extent Will Past Releases Contaminate Community Water Supply Wells? Environmental Science & Technology, 34(9), 210A-217A.

Kannan, G., & Anand, R. (2011). Experimental investigation on diesel engine with diestrol–water micro emulsions. Energy, 36(3), 1680-1687.

Karaosmanoğlu, Filiz Işiğigür, & Ayşe, A. A. a. H. (1997). Methanol-unleaded gasoline blends containing fusel oil fraction as spark ignition engine fuel. Energy sources, 19(6), 567-577.

Karaosmanoğlu, F., Işiğigür-Ergüdenler, A., & Ayşe Aksoy, H. (1998). Alcohol fuel research in Turkey. Energy sources, 20(10), 955-960.

Karaosmanoğlu, F., Işiğigür, A., & Aksoy, H. A. (1997). Methanol-unleaded gasoline blends containing fusel oil fraction as spark ignition engine fuel. Energy sources, 19(6), 567-577.

Karaosmanoğlu, F., Işığıgür, A., Soruşbay, C., & Aksoy, H. (1991). Methanol-gasoline blends as alternative engine fuel. Paper presented at the IX. International symposium on alcohol fuel (ISAF).

Karavalakis, G., Short, D., Vu, D., Villela, M., Asa-Awuku, A., & Durbin, T. D. (2014). Evaluating the regulated emissions, air toxics, ultrafine particles, and black carbon from SI-PFI and SI-DI vehicles operating on different ethanol and iso-butanol blends. Fuel, 128, 410-421.

Kiani, M. K. D., Ghobadian, B., Tavakoli, T., Nikbakht, A., & Najafi, G. (2010). Application of artificial neural networks for the prediction of performance and exhaust emissions in SI engine using ethanol-gasoline blends. Energy, 35(1), 65-69.

Kim, M. Y., Yoon, S. H., Ryu, B. W., & Lee, C. S. (2008). Combustion and emission characteristics of DME as an alternative fuel for compression ignition engines with a high pressure injection system. Fuel, 87(12), 2779-2786.

Kumar, S., Cho, J. H., Park, J., & Moon, I. (2013). Advances in diesel–alcohol blends and their effects on the performance and emissions of diesel engines. Renewable and Sustainable Energy Reviews, 22, 46-72. doi: http://dx.doi.org/10.1016/j.rser.2013.01.017

Lanzanova, T. D. M., Dalla Nora, M., & Zhao, H. (2016). Performance and economic analysis of a direct injection spark ignition engine fueled with wet ethanol. Applied Energy, 169, 230-239. doi: http://dx.doi.org/10.1016/j.apenergy.2016.02.016

Lapuerta, M., Armas, O., & García-Contreras, R. (2009). Effect of ethanol on blending stability and diesel engine emissions. Energy & Fuels, 23(9), 4343-4354.

Leblanc, G., Secco, R., & Kostic, M. (1999). Viscosity measurement. The measurement, instrumentation and sensors handbook on CD-ROM.

Lee, P.-R., Yu, B., Curran, P., & Liu, S.-Q. (2011). Effect of fusel oil addition on volatile compounds in papaya wine fermented with Williopsis saturnus var. mrakii NCYC 2251. Food Research International, 44(5), 1292-1298.

Lee, S. B., Han, K. H., Lee, J. D., & Hong, I. K. (2010). Optimum process and energy density analysis of canola oil biodiesel synthesis. Journal of Industrial and Engineering Chemistry, 16(6), 1006-1010.

Li, S., Li, W., Xu, M., Wang, X., Li, H., & Lu, Q. (2015). The experimental study on nitrogen oxides and SO2 emission for oxy-fuel circulation fluidized bed combustion with high oxygen concentration. Fuel, 146(0), 81-87. doi: http://dx.doi.org/10.1016/j.fuel.2014.12.089

Liang, C., Ji, C., Gao, B., Liu, X., & Zhu, Y. (2012). Investigation on the performance of a spark-ignited ethanol engine with DME enrichment. Energy Conversion and Management, 58, 19-25. doi: http://dx.doi.org/10.1016/j.enconman.2012.01.004

Licht, F. (2007). World ethanol and biofuels report. World Ethanol Trade Hits Record Volume, 5(22), 453-457.

Lif, A., & Holmberg, K. (2006). Water-in-diesel emulsions and related systems. Advances in colloid and interface science, 123, 231-239.

Lipnizki, F., Field, R. W., & Ten, P.-K. (1999). Pervaporation-based hybrid process: a review of process design, applications and economics. Journal of Membrane Science, 153(2), 183-210.

Liu, Y., Liu, H., Zhang, J., Cheng, K., & Chen, Z. (2008). Research progress in new biofuel butanol. Mod Chem Ind, 28(6), 28-33.

Liwarska-Bizukojc, E., & Ledakowicz, S. (2003). Stoichiometry of the aerobic biodegradation of the organic fraction of municipal solid waste (MSW). Biodegradation, 14(1), 51-56.

Luque, R., & Clark, J. (2010). Handbook of biofuels production: Processes and technologies: Elsevier.

Mack, J. H., Aceves, S. M., & Dibble, R. W. (2009). Demonstrating direct use of wet ethanol in a homogeneous charge compression ignition (HCCI) engine. Energy, 34(6), 782-787. doi: http://dx.doi.org/10.1016/j.energy.2009.02.010

Mahfud, F. H., Melián-Cabrera, I., Manurung, R., & Heeres, H. J. (2007). Biomass to Fuels: Upgrading of Flash Pyrolysis Oil by Reactive Distillation Using a High Boiling Alcohol and Acid Catalysts. Process Safety and Environmental Protection, 85(5), 466-472. doi: http://dx.doi.org/10.1205/psep07013

mat Yasin, M. H., Mamat, R., Yusop, A. F., Rahim, R., Aziz, A., & Shah, L. A. (2013). Fuel physical characteristics of biodiesel blend fuels with alcohol as additives. Procedia Engineering, 53, 701-706.

Max, D. (1908). max maerckers handbuch der spiritus fabrikation. 1004 pp illus Berlin Edmonds Wm J and Stengel Leonard A(ed 9).

Mayer, F. D., Feris, L. A., Marcilio, N. R., & Hoffmann, R. (2015). Why small-scale fuel ethanol production in Brazil does not take off? Renewable and Sustainable Energy Reviews, 43, 687-701. doi: http://dx.doi.org/10.1016/j.rser.2014.11.076

Megaritis, A., Yap, D., & Wyszynski, M. (2007). Effect of water blending on bioethanol HCCI combustion with forced induction and residual gas trapping. Energy, 32(12), 2396-2400.

Megaritis, A., Yap, D., & Wyszynski, M. L. (2008). Effect of inlet valve timing and water blending on bioethanol HCCI combustion using forced induction and residual gas trapping. Fuel, 87(6), 732-739. doi: http://dx.doi.org/10.1016/j.fuel.2007.05.007

Methanol safe handling manual. (January, 2013). Methanol Institute. from www.methanol.org

Minteer, S. (2006). Alcoholic fuels: CRC Press.

Mislavskaya, V., Leonov, V., Mislavskii, N., & Ryzhak, I. (1982). Conditions of phase stability in a gasoline-methanol-cyclohexanol-water system. Sov. Chem. Ind.(Engl. Transl.);(United States), 14(3).

Misra, R. D., & Murthy, M. S. (2011). Blending of additives with biodiesels to improve the cold flow properties, combustion and emission performance in a compression ignition engine—A review. Renewable and Sustainable Energy Reviews, 15(5), 2413-2422. doi: http://dx.doi.org/10.1016/j.rser.2011.02.023

Mittelbach, M., & Remschmidt, C. (2004). Biodiesel: the comprehensive handbook: Martin Mittelbach.

Mofijur, M., Rasul, M., Hyde, J., Azad, A., Mamat, R., & Bhuiya, M. (2016). Role of biofuel and their binary (diesel–biodiesel) and ternary (ethanol–biodiesel–diesel) blends on internal combustion engines emission reduction. Renewable and Sustainable Energy Reviews, 53, 265-278.

Mohamad, T. I., & How, H. G. (2014). Part-load performance and emissions of a spark ignition engine fueled with RON95 and RON97 gasoline: Technical viewpoint on Malaysia's fuel price debate. Energy Conversion and Management, 88, 928-935.

Montgomery, D. C. (2008). Design and analysis of experiments: John Wiley & Sons.

MONTGOMERY, D. C. (2013). Design and Analysis of Experiments Eighth Edition. New York: ohnWiley & Sons.

Mueller, S. A., Anderson, J. E., Wallington, T. J., & Hammond, R. M. (2009). A Classroom Demonstration of Water-Induced Phase Separation of Alcohol–Gasoline Biofuel Blends. J. Chem. Educ, 86(9), 1045.

Mustafa, B. M. K. S. C. C. (2014). The effect of different alcohol fuels on the performance, emission and combustion characteristics of a gasoline engine. Fuel, 115, 901-906. doi: http://dx.doi.org/10.1016/j.fuel.2012.09.020

Neale, M. (1988). Rapid high-performance liquid chromatography method for determination of ethanol and fusel oil in the alcoholic beverage industry. Journal of Chromatography A, 447, 443-450.

Nemestóthy, N., Bélafi-Bakó, K., Bartha, L., Gubicza, L., & Bányai, T. (2012). Biotechnological Utilisation of Fusel Oil for Biolubricant Production: INTECH Open Access Publisher.

Nithyanandan, K., Wu, H., Huo, M., & Lee, C.-F. (2014). A Preliminary Investigation of the Performance and Emissions of a Port-Fuel Injected SI Engine Fueled with Acetone-Butanol-Ethanol (ABE) and Gasoline: SAE Technical Paper.

Nithyanandan, K., Zhang, J., Li, Y., Wu, H., Lee, T. H., Lin, Y., & Chia-fon, F. L. (2016). Improved SI engine efficiency using Acetone–Butanol–Ethanol (ABE). Fuel.

Niven, R. K. (2005). Ethanol in gasoline: environmental impacts and sustainability review article. Renewable and Sustainable Energy Reviews, 9(6), 535-555. doi: http://dx.doi.org/10.1016/j.rser.2004.06.003

Noordin, M. Y., Venkatesh, V. C., Sharif, S., Elting, S., & Abdullah, A. (2004). Application of response surface methodology in describing the performance of coated carbide tools when turning AISI 1045 steel. Journal of Materials Processing Technology, 145(1), 46-58.

Normann, F., Andersson, K., Leckner, B., & Johnsson, F. (2009). Emission control of nitrogen oxides in the oxy-fuel process. Progress in energy and combustion science, 35(5), 385-397.

Ong, H. C., Mahlia, T. M. I., & Masjuki, H. H. (2012). A review on energy pattern and policy for transportation sector in Malaysia. Renewable and Sustainable Energy Reviews, 16(1), 532-542. doi: http://dx.doi.org/10.1016/j.rser.2011.08.019

Osten, D. W., & Sell, N. J. (1983). Methanol-gasoline blends: blending agents to prevent phase separation. Fuel, 62(3), 268-270.

Özgülsün, A., & Karaosmanoğlu, F. (1999). Environmentally friendly lubricating oil candidate. Paper presented at the Twentieth Symposium on Biotechnology for Fuels and Chemicals.

Palmer, F. (1986). Vehicle performance of gasoline containing oxygenates. Paper presented at the INTERNATIONAL CONFERENCE ON PETROLEUM BASED FUELS AND AUTOMOTIVE APPLICATIONS. IMECHE CONFERENCE PUBLICATIONS 1986-11. PAPER NO C319/86.

Pandey, R. K., Rehman, A., & Sarviya, R. (2012). Impact of alternative fuel properties on fuel spray behavior and atomization. Renewable and Sustainable Energy Reviews, 16(3), 1762-1778.

Parag, S., & Raghavan, V. (2009). Experimental investigation of burning rates of pure ethanol and ethanol blended fuels. Combustion and Flame, 156(5), 997-1005. doi: http://dx.doi.org/10.1016/j.combustflame.2008.10.011

Patil, A., Koolwal, S., & Butala, H. (2002). Fusel oil: composition, removal and potential utilization. International sugar journal, 104(1238), 51-58.

Patil AG, K. S., Butala HD. . (2002). Fusel oil: composition, removal, and potential utilization. . Int Sugar J., 104(:51-58.), 8.

Pelkmans, L., Govaerts, L., & Kessels, K. (2008). Inventory of biofuel policy measures and their impact on the market. Report of ELOBIO subtasks, 2.1-2.2.

Pimentel, D., Berger, B., Filiberto, D., Newton, M., Wolfe, B., Karabinakis, E., . . . Nandagopal, S. (2004). Water resources: agricultural and environmental issues. BioScience, 54(10), 909-918.

Poulopoulos, S., Samaras, D., & Philippopoulos, C. (2001). Regulated and unregulated emissions from an internal combustion engine operating on ethanol-containing fuels. Atmospheric Environment, 35(26), 4399-4406.

Pourkhesalian, A. M., Shamekhi, A. H., & Salimi, F. (2010). Alternative fuel and gasoline in an SI engine: A comparative study of performance and emissions characteristics. Fuel, 89(5), 1056-1063. doi: http://dx.doi.org/10.1016/j.fuel.2009.11.025

Qi, D., Liu, S. Q., Zhang, C. H., & Bian, Y. Z. (2005). Properties, performance, and emissions of methanol-gasoline blends in a spark ignition engine. Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, 219(3), 405-412.

Rahman, S. A., Masjuki, H., Kalam, M., Abedin, M., Sanjid, A., & Sajjad, H. (2013). Production of palm and Calophyllum inophyllum based biodiesel and investigation of blend performance and exhaust emission in an unmodified diesel engine at high idling conditions. Energy Conversion and Management, 76, 362-367.

Rajan, S., & Saniee, F. F. (1983). Water—ethanol—gasoline blends as spark ignition engine fuels. Fuel, 62(1), 117-121. doi: http://dx.doi.org/10.1016/0016-2361(83)90265-X

Rajasekar, E., Murugesan, A., Subramanian, R., & Nedunchezhian, N. (2010). Review of NOx reduction technologies in CI engines fuelled with oxygenated biomass fuels. Renewable and Sustainable Energy Reviews, 14(7), 2113-2121. doi: http://dx.doi.org/10.1016/j.rser.2010.03.005

Ramadhas, A. S. (2016). Alternative fuels for transportation: CRC Press.

Ramadhas, A. S., Muraleedharan, C., & Jayaraj, S. (2005). Performance and emission evaluation of a diesel engine fueled with methyl esters of rubber seed oil. Renewable Energy, 30(12), 1789-1800. doi: http://dx.doi.org/10.1016/j.renene.2005.01.009

Ramulu, U. (1995). Recycling of Crop, Animal and Industrial Wastes in Agriculture. Journal of the Indian Society of Soil Science, 43(1), 147-148.

Rask, K. N. (1998). Clean air and renewable fuels: the market for fuel ethanol in the US from 1984 to 1993. Energy Economics, 20(3), 325-345.

Raveendran, K., & Ganesh, A. (1996). Heating value of biomass and biomass pyrolysis products. Fuel, 75(15), 1715-1720.

Reed, T. B., & Lerner, R. (1973). Methanol: a versatile fuel for immediate use. Science, 182(4119), 1299-1304.

Reijnders, L., & Huijbregts, M. (2008). Biofuels for road transport: a seed to wheel perspective: Springer Science & Business Media.

Robinson, T. R. (1976). The health of long service tetraethyl lead workers. Journal of Occupational and Environmental Medicine, 18(1), 31-40.

Rodríguez-Antón, L. M., Gutíerrez-Martín, F., & Doce, Y. (2016). Physical properties of gasoline, isobutanol and ETBE binary blends in comparison with gasoline ethanol blends. Fuel, 166, 73-78. doi: http://dx.doi.org/10.1016/j.fuel.2015.10.106

Rowe, R. L., Street, N. R., & Taylor, G. (2009). Identifying potential environmental impacts of large-scale deployment of dedicated bioenergy crops in the UK. Renewable and Sustainable Energy Reviews, 13(1), 271-290.

Sarathy, S. M., Thomson, M. J., Togbé, C., Dagaut, P., Halter, F., & Mounaim-Rousselle, C. (2009). An experimental and kinetic modeling study of n-butanol combustion. Combustion and Flame, 156(4), 852-864. doi: http://dx.doi.org/10.1016/j.combustflame.2008.11.019

Schifter, I., Diaz, L., Rodriguez, R., Gómez, J., & Gonzalez, U. (2011). Combustion and emissions behavior for ethanol–gasoline blends in a single cylinder engine. Fuel, 90(12), 3586-3592.

Schoondermark-Stolk, S. A., Tabernero, M., Chapman, J., Schure, E. G., Verrips, C. T., Verkleij, A. J., & Boonstra, J. (2005). Bat2p is essential in Saccharomyces cerevisiae for fusel alcohol production on the non-fermentable carbon source ethanol. FEMS yeast research, 5(8), 757-766.

Schulthess, D., & Ettlinger, L. (1978). Influence of the concentration of branched chain amino acids on the formation of fusel alcohols. Journal of the Institute of Brewing, 84(4), 240-243.

Schwartz, M. M. (1979). Metals Joining Manual.(Book). McGraw-Hill Book Co., Chapters paged separately, 1979.

Semelsberger, T. A., Borup, R. L., & Greene, H. L. (2006). Dimethyl ether (DME) as an alternative fuel. Journal of Power Sources, 156(2), 497-511.

Shah, P. R., & Ganesh, A. (2016). A comparative study on influence of fuel additives with edible and non-edible vegetable oil based on fuel characterization and engine characteristics of diesel engine. Applied thermal engineering, 102, 800-812.

Sharma, A., & Murugan, S. (2015). Combustion, performance and emission characteristics of a DI diesel engine fuelled with non-petroleum fuel: A study on the role of fuel injection timing. Journal of the Energy Institute, 88(4), 364-375. doi: http://dx.doi.org/10.1016/j.joei.2014.11.006

Shell. (2016). Fuel Pump Sales and LPG ceiling prices. from http://www.turkiyeshell.com/pompatest/History.aspx

Sheng, C., & Azevedo, J. (2005). Estimating the higher heating value of biomass fuels from basic analysis data. Biomass and Bioenergy, 28(5), 499-507.

Sheng, C., & Azevedo, J. L. T. (2005). Estimating the higher heating value of biomass fuels from basic analysis data. Biomass and Bioenergy, 28(5), 499-507. doi: http://dx.doi.org/10.1016/j.biombioe.2004.11.008

Smith, J. L., & Workman, J. P. (1980). Alcohol for motor fuels: Colorado State University Extension Service.

Solmaz, H. (2015). Combustion, performance and emission characteristics of fusel oil in a spark ignition engine. Fuel Processing Technology, 133, 20-28.

Solomon, B. D., Barnes, J. R., & Halvorsen, K. E. (2007). Grain and cellulosic ethanol: History, economics, and energy policy. Biomass and Bioenergy, 31(6), 416-425.

Song, C.-L., Zhang, W.-M., Pei, Y.-Q., Fan, G.-L., & Xu, G.-P. (2006). Comparative effects of MTBE and ethanol additions into gasoline on exhaust emissions. Atmospheric Environment, 40(11), 1957-1970.

Sorapipatana, C., & Yoosin, S. (2011). Life cycle cost of ethanol production from cassava in Thailand. Renewable and Sustainable Energy Reviews, 15(2), 1343-1349. doi: http://dx.doi.org/10.1016/j.rser.2010.10.013

Squillace, P. J., Pankow, J. F., Korte, N. E., & Zogorski, J. S. (1997). Review of the environmental behavior and fate of methyl tert-butyl ether. Environmental Toxicology and Chemistry, 16(9), 1836-1844.

Squillace, P. J., Zogorski, J. S., Wilber, W. G., & Price, C. V. (1996). Preliminary assessment of the occurrence and possible sources of MTBE in groundwater in the United States, 1993-1994. Environmental Science & Technology, 30(5), 1721-1730.

Stephenson, R. M. (1992). Mutual solubilities: water-ketones, water-ethers, and water-gasoline-alcohols. Journal of Chemical and Engineering Data, 37(1), 80-95.

Stone, R. (1999). Introduction to internal combustion engines.

Streimikiene, D., & Šivickas, G. (2008). The EU sustainable energy policy indicators framework. Environment International, 34(8), 1227-1240.

Sulaiman, S. A., Karim, M. F., Nazmi, M., Moni, Z., & Atnaw, S. M. (2013). On gasification of different tropical plant-based biomass materials. Asian Journal of Scientific Research, 6(2), 245.

Szwaja, S., Kovacs, V. B., Bereczky, A., & Penninger, A. (2013). Sewage sludge producer gas enriched with methane as a fuel to a spark ignited engine. Fuel Processing Technology, 110, 160-166.

Szwaja, S., & Naber, J. D. (2010). Combustion of n-butanol in a spark-ignition IC engine. Fuel, 89(7), 1573-1582. doi: http://dx.doi.org/10.1016/j.fuel.2009.08.043

Taylor, E. J., Campbell, S. G., Griffiths, C. D., Reid, P. J., Slaven, J. W., Harrison, R. J., . . . Ashe, M. P. (2010). Fusel alcohols regulate translation initiation by inhibiting eIF2B to reduce ternary complex in a mechanism that may involve altering the integrity and dynamics of the eIF2B body. Molecular biology of the cell, 21(13), 2202-2216.

Telmo, C., Lousada, J., & Moreira, N. (2010). Proximate analysis, backwards stepwise regression between gross calorific value, ultimate and chemical analysis of wood. Bioresource technology, 101(11), 3808-3815.

Thomas, V., & Kwong, A. (2001). Ethanol as a lead replacement: phasing out leaded gasoline in Africa. Energy policy, 29(13), 1133-1143.

Thorne, R. (1941). The growth and fermentation of a strain of S. cerevisiae with amino acids as nutrients. Journal of the Institute of Brewing, 47(5), 255-272.

Tsai, W.-T., Lan, H.-F., & Lin, D.-T. (2008). An analysis of bioethanol utilized as renewable energy in the transportation sector in Taiwan. Renewable and Sustainable Energy Reviews, 12(5), 1364-1382. doi: http://dx.doi.org/10.1016/j.rser.2007.01.006

U.S. Department of Energy. (accessed 19.04.2016). Alternative fuel vehicle in use. from http://www.afdc.energy.gov/data/10300

Vassilev, S. V., & Vassileva, C. G. (2016). Composition, properties and challenges of algae biomass for biofuel application: An overview. Fuel, 181, 1-33. doi: http://dx.doi.org/10.1016/j.fuel.2016.04.106

Vauclair, C., Tarjus, H., & Schaetzel, P. (1997). Permselective properties of PVA-PAA blended membrane used for dehydration of fusel oil by pervaporation. Journal of Membrane Science, 125(2), 293-301.

Verbeek, R., & Van der Weide, J. (1997). Global assessment of dimethyl-ether: comparison with other fuels: SAE Technical Paper.

Von Krauss, M. K., & Harremoës, P. (2001). MTBE in petrol as a substitute for lead. Late lessons from early warnings: the precautionary principle 1896–2000, 110.

Wallner, T., Miers, S. A., & McConnell, S. (2009). A comparison of ethanol and butanol as oxygenates using a direct-injection, spark-ignition engine. Journal of Engineering for Gas Turbines and Power, 131(3), 032802.

Wang, C., Xu, H., Daniel, R., Ghafourian, A., Herreros, J. M., Shuai, S., & Ma, X. (2013a). Combustion characteristics and emissions of 2-methylfuran compared to 2,5-dimethylfuran, gasoline and ethanol in a DISI engine. Fuel, 103, 200-211. doi: http://dx.doi.org/10.1016/j.fuel.2012.05.043

Wang, C., Xu, H., Daniel, R., Ghafourian, A., Herreros, J. M., Shuai, S., & Ma, X. (2013b). Combustion characteristics and emissions of 2-methylfuran compared to 2, 5-dimethylfuran, gasoline and ethanol in a DISI engine. Fuel, 103, 200-211.

Wang, J., Chen, H., Liu, B., & Huang, Z. (2008). Study of cycle-by-cycle variations of a spark ignition engine fueled with natural gas–hydrogen blends. International journal of hydrogen energy, 33(18), 4876-4883.

Webb, A. D., & Ingraham, J. L. (1963). Fusel oil. Adv. Appl. Microbiol, 5, 317-353.

Webb, A. D., Kepner, R. E., & Ikeda, R. M. (1952). Composition of typical grape brandy fusel oil. Analytical Chemistry, 24(12), 1944-1949.

Welsh, F. W., & Williams, R. E. (1989). Lipase mediated production of flavor and fragrance esters from fusel oil. Journal of food science, 54(6), 1565-1568.

White, T. L. (1907). Alcohol as a Fuel for the Automobile Motor: SAE Technical Paper.

Wrage, K., & Goering, C. (1980). Technical feasibility of diesohol. Transactions of the ASAE, 23(6), 1338-1343.

Yacoub, Y., Bata, R., & Gautam, M. (1998). The performance and emission characteristics of C1-C5 alcohol-gasoline blends with matched oxygen content in a single-cylinder spark ignition engine. Proceedings of the Institution of Mechanical Engineers, Part A: Journal of Power and Energy, 212(5), 363-379.

Yakup Icingur , A. C. (2012). The effects of the blends of fusel oil and gasoline on performance and emissions in a spark ignition engine. Journal of the Faculty of Engineering and Architecture of Gazi University, 27(1), 143-149.

Yasin, M. M., Yusaf, T., Mamat, R., & Yusop, A. F. (2014). Characterization of a diesel engine operating with a small proportion of methanol as a fuel additive in biodiesel blend. Applied Energy, 114, 865-873.

Yaws, C. L., & Gabbula, C. (2003). Yaws" Handbook of Thermodynamic and Physical Properties of Chemical Compounds: Knovel.

Yeliana, Y., Cooney, C., Worm, J., & Naber, J. (2008). The calculation of mass fraction burn of ethanol-gasoline blended fuels using single and two-zone models: SAE Technical Paper.

Yin, C.-Y. (2011). Prediction of higher heating values of biomass from proximate and ultimate analyses. Fuel, 90(3), 1128-1132. doi: http://dx.doi.org/10.1016/j.fuel.2010.11.031

Yücesu, H. S., Topgül, T., Çinar, C., & Okur, M. (2006). Effect of ethanol–gasoline blends on engine performance and exhaust emissions in different compression ratios. Applied thermal engineering, 26(17–18), 2272-2278. doi: http://dx.doi.org/10.1016/j.applthermaleng.2006.03.006

Yuen, P. K. P., Villaire, W., & Beckett, J. (2010). Automotive Materials Engineering Challenges and Solutions for the Use of Ethanol and Methanol Blended Fuels: SAE Technical Paper.

Yüksel, F., & Yüksel, B. (2004). The use of ethanol–gasoline blend as a fuel in an SI engine. Renewable Energy, 29(7), 1181-1191. doi: http://dx.doi.org/10.1016/j.renene.2003.11.012

Yusri, I., Mamat, R., Azmi, W., Najafi, G., Sidik, N., & Awad, O. I. (2016). Experimental investigation of combustion, emissions and thermal balance of secondary butyl alcohol-gasoline blends in a spark ignition engine. Energy Conversion and Management, 123, 1-14.

Yusri, I. M., Mamat, R., Azmi, W. H., Najafi, G., Sidik, N. A. C., & Awad, O. I. (2016). Experimental investigation of combustion, emissions and thermal balance of secondary butyl alcohol-gasoline blends in a spark ignition engine. Energy Conversion and Management, 123, 1-14. doi: http://dx.doi.org/10.1016/j.enconman.2016.05.082

Zhang, Z., Wang, T., Jia, M., Wei, Q., Meng, X., & Shu, G. (2014). Combustion and particle number emissions of a direct injection spark ignition engine operating on ethanol/gasoline and n-butanol/gasoline blends with exhaust gas recirculation. Fuel, 130, 177-188. doi: http://dx.doi.org/10.1016/j.fuel.2014.04.052

Zhen, X., & Wang, Y. (2015). An overview of methanol as an internal combustion engine fuel. Renewable and Sustainable Energy Reviews, 52, 477-493. doi: http://dx.doi.org/10.1016/j.rser.2015.07.083

Zhuang, Y., & Hong, G. (2013). Primary investigation to leveraging effect of using ethanol fuel on reducing gasoline fuel consumption. Fuel, 105, 425-431.